BIOQUAL '88

APPLYING BIOTECHNOLOGY
FOR
ENVIRONMENTAL PROTECTION

LES APPLICATIONS DE LA
BIOTECHNOLOGIE À LA
PROTECTION DE L'ENVIRONNEMENT

SUPPORT LITERATURE

DOCUMENTATION

Canada

90-02623/

BIOQUAL '88 PROGRAM CHANGES

TECHNICAL PROGRAM

WEDNESDAY, OCTOBER 19, 1988

Additional Presenter, Biodegradation Workshop "B"

1. Pierre Lupien
   Cartier/Monenco

Change, Biomonitoring Workshop "C"

1. "Biomonitoring and the New Canadian Environmental Protection Act"
   Terry McIntyre, Environment Canada and John Smith, Health and Welfare

2. "New Applications of Biotechnology to Biomonitoring"
   Shawn Severn, CBR, (Chemistry Biotechnology Research Inc.,)

THURSDAY, OCTOBER 20, 1988

SESSION II - Auditorium

1. Chair - Marty Samoiloff

BIOQUAL

TABLE OF CONTENTS/TABLES DES MATIÈRES

PROGRAM

BIOQUAL '88 Final Program

Abstracts and Brief

Biographical Resumes

BIOQUAL Steering Committee Members

Exhibits and Posters

Notes

PROGRAMME

Programme final BIOQUAL '88

Resumés de présentations

Apeçus biographiques

Membres du Comité de direction du réseau BIOQUAL

Expositions et espaces d'affichage

Notes

FINAL PROGRAM

PROGRAMME FINAL

TECHNICAL PROGRAM
CANADA CENTRE FOR INLAND WATERS
BURLINGTON, ONTARIO
OCTOBER 18-21, 1988

OCTOBER 18

8:00	Bus Leaves Holiday Inn for Venture Inn
8:15	Bus Leaves Holiday Inn for CCIW
8:00 - 9:00	Workshop Registration in CCIW Lobby
9:00 - 16:30	Microbiology - Ecotoxicology Workshop - North and South Seminar Rooms
17:00	Bus Leaves to Hotels
18:00 - 22:00	Welcome Wine and Cheese Reception and Evening Registration, Nelson Room (lower level), Venture Inn

OCTOBER 19

7:00 - 9:00	Speakers Breakfast - Pat and Mario's adjacent to Venture Inn
8:00	Bus Leaves Holiday Inn for Venture Inn
8:15	Bus Leaves Venture Inn for CCIW
7:00 - 9:00	Registration at CCIW (Registration Desk Open for Duration of Bioqual 88) 1- Lunch and banquet tickets are included with the registration. Additional banquet tickets are available at the registration desk. 2- For those taking the tours and wishing bus transportation to the Pearson International Airport (Toronto) for Friday evening flights please advise the registration desk.

SESSION I - AUDITORIUM

9:00 - 9:15	Introduction - **P. Matteau**, Biotechnology Co-ordinator, National Research Council Ottawa, Ontario
9:15 - 10:00	"Monitoring Food and Environmental Samples for Toxic Chemical Residues by Inmunoassay" **Martin Vanderlaan** Lawrence-Livermore National Laboratory University of California, Livermore, California
10:00 - 10:45	"Biotechnology Research Program in EPA - Risk Assessment and Bioremediation" **A. Pritchard** Environmental Research Laboratory Sabine Island Gulf Breeze, Florida
10:45 - 11:30	Refreshment Break, outside auditorium
	Chair: **Martyn Riddle**, Monenco Consultants Ltd. Rexdale, Ontario
11:30 - 12:15	"A Field/Laboratory Evaluation of In-situ Biodegradation of Chlorinated Aliphatics (Ethenes)" **L. Semprini** Department of Civil Engineering Stanford University California, U.S.A.
12:15 - 13:00	"Bioqual's Strategic Plan" A Presentation by the Bioqual Steering Committee **Marty Samoiloff** Bioquest International Inc. Winnipeg, Manitoba
13:00 - 14:00	Lunch at CCIW Cafeteria

WORKSHOPS

14:00 - 16:00 Three concurrent workshops provide members an opportunity to discuss their related projects.

A. BIOPROCESS ENGINEERING

MODERATORS

Kevin Kennedy
National Research Council of Canada
Ottawa, Ontario

Ray Stickney
Canviro Consultants
Waterloo, Ontario

This workshop will focus on a number of innovative bioprocesses through presentations on:

"New Biosolvant Materials for Removal/Recovery of Heavy Metals from Effluents"
B. Volesky and N. Kayucak
McGill University

"Microbial Attachment on Various Support Media"
R. Cullimore
Regina Water Resources Institute

"Design and Operation of Aerated Facultative Lagoons for Removal of Chlorinated Organic Compounds from Kraft Mill Effluent"
D. Grant
University of Toronto

"Anaerobic Treatment of Landfill Leachate"
P. Wright
Porter-Dillon
Halifax, Nova Scotia

"Photobioreactor System for Treatment of Toxic Industrial Effluents"
N. Kosaric
University of Western Ontario

B - BIODEGRADATION - SOUTH SEMINAR ROOM

MODERATORS

Martyn Riddle
Monenco Consultants Ltd.
Rexdale, Ontario

Terri Bulman
Environment Canada
Burlington, Ontario

The theme of this workshop is in-situ bioremediation which offers a most cost-effective method of remediating contaminated sites when compared to alternative cleanup technologies. The problems that are currently limiting the increased use of in-situ remediation in Canada will be discussed based on presentations by:

Howard Carter
Texaco Canada

Murray Jones
Shell Canada

Diana Mourato
The Sanivan Group

Tony Ying
Treatek Limited

Keith Piotech
CH2M Hill

Michael Barnhart
Waste Stream Technology Inc.

David Jones
Canadian Waste Management

Bob Dalrymple
Ontario Ministry of Environment

Paul Voroney
University of Guelph

Charles Greer
National Research Council

Joe Fu
Keystone Environmental Resources

C - BIOMONITORING - AUDITORIUM

MODERATOR **Marty Samoiloff**
Bioquest International Inc.
Winnipeg, Manitoba

This workshop will include presentations on:

"Biomonitoring and the New Canadian Environmental Protection Act"
Terry McIntyre
Environment Canada

"Strategies for Quality Control and Quality Assurance for Biomonitoring"
Bill Evans
University of Winnipeg

"Detection of Contaminants in Environmental Samples using Radioimmunoassey Techniques"
Jim Sherry
National Water Research Institute

"The Coliform Test (CE) as an Alternative Monitoring Technique"
Peter Nix
EVS Consultants

"Monitoring Bacterial Populations in Biofouled Waters and Wastewaters"
Roy Cullimore
Regina Water Resources Institute

Refreshments will be available in each workshop area.

17:00	Bus Leaves CCIW to Burlington Golf and Country Club. For those using private vehicles consult map available at the Registration Desk
17:15 - 18:45	Cash Bar with Adam Cook at the grand piano
18:45 - 21:00	Banquet - Burlington Golf and Country Club

SPEAKER "Biotechnology Strategy Update"
Louise McArthur
Industrial Support and Strategic Technologies Branch, Ministry of State, Science and Technology
Ottawa, Ontario

21:15 Bus Leaves for Hotels

OCTOBER 20

7:00 - 8:00 Speakers Breakfast - Pat and Mario's adjacent to Venture Inn

8:00 Bus Leaves Holiday Inn for Venture Inn

8:15 Bus Leaves Venture Inn for CCIW

7:00 - 9:00 Bioqual Registration
CCIW

SESSION II - AUDITORIUM

CHAIR **Lou Visentin**
Memorial University of Newfoundland
St. John's, Newfoundland

9:00 - 9:45 "Effluent Bioassays in Ontario's MISA Program"
Gary Westlake
Ontario Ministry of the Environment
Rexdale, Ontario

9:45 - 10:45 A Series of Mini-Presentations Highlighting Poster Displays

"Detection of Coliform Bacteria in Drinking Water Using the Coliform Equivalent (CE) Test"
P. G. Nix and D. B. Holmes
EVS Consultants Ltd.
North Vancouver, B.C.

"Microbiological Regeneration of Granular Activated Carbon Industrial Wastewater Treatment"
C. W. Robinson
Department of Chemical Engineering
University of Waterloo
Waterloo, Ontario

"First Canadian Full Scale Biological Aerated Filter for Wastewater Treatment - Orford, Québec"
A. Kantardjieff
Groupe Teknika
Sherbrooke, Québec

"High Rate Anaerobic Treatment of a Landfill Leachate - The Halifax Experience"
P. Wright
Porter-Dillon Ltd.
Halifax, Nova Scotia

10:45 - 11:30 Refreshments - Outside Auditorium

CHAIR **Earl Shannon**
Canviro Consultants
Waterloo, Ontario

11:30 - 12:15 "Membranes in Biotechnology - A Research and Development Case Study"
R. D. Thomson, B. M. Duffy and L. Fabbriano
Zenon Environmental Inc.
Burlington, Ontario

A. L. Nguyen
Biotechnology Research Institute
National Research Council
Montréal, Québec

12:15 - 13:00 "Biologically Fouled Water Well Monitoring and Restoration"
R. Cullimore, Regina Water Resources Inst.
Regina, Saskatchewan

13:00 - 14:00 Luncheon at CCIW Cafeteria

SESSION III - AUDITORIUM

14:00 - 15:30 Strategic Partnerships in Biotechnology

CHAIR **George Hill**
Environment Canada
Ottawa, Ontario

"NSERC - A Partner in Biotechnology Research"
Steve Shugar
Assistant Director
Strategic Grants Program
Natural Sciences and Engineering Research Council
Ottawa, Ontario

"Update on the Scope and Operations of NRC's Industrial Research Assistance Program and Highlights of Recent R&D Tax Changes"
Denys Cooper
Project Manager
IRAP Laboratory Network
National Research Council of Canada
Ottawa, Ontario

"Partnerships in Biotechnology"
Elizabeth Dickson
Director
Biotechnology and Health Care Products Directorate
Department of Industry, Science and Technology
Ottawa, Ontario

15:30 - 16:00 Refreshments - Outside Auditorium

16:00 - 16:45 Bioqual 88 Synopsis

CHAIR **Steve Hart**
Bioqual Coordinator
Environment Canada
Ottawa, Ontario

RAPPORTEURS

"Biomonitoring, Biosensing and Biodegradation"
Ian Forrester
Gemini Biochemical Research Limited
Calgary, Alberta

"Bioprocess Engineering"
Keith Murphy
McMaster University
Hamilton, Ontario

17:00 Bus Leaves for Hotels

OCTOBER 21

8:00 Bus Leaves Holiday Inn for Venture Inn

8:15 Bus Leaves Venture Inn for CCIW

TOUR A

Guelph Area

Leader: **Ray Stickney**
Canviro Consultants
Waterloo, Ontario
Departure time: 9:00

TOUR B

Niagara River

Leader: **Murray Brooksbank**
Great Lakes Environment Office
Conservation and Protection
Ontario Region
Toronto, Ontario
Departure time: 8:30

For transportation to Pearson International Airport from CCIW please consult the Registration Desk by 12:00 on Thursday.

ABSTRACTS AND BIOGRAPHICAL RÉSUMÉS

RÉSUMÉS DE PRÉSENTATIONS ET APERCUS BIOGRAPHIQUES

SESSION I

Monitoring Food and Environmental Samples for Toxic Chemical Residues by Immunoassay.

Martin Vanderlaan, Bruce Watkins and Larry Stanker, Biomedical Sciences Division, Lawrence Livermore National Laboratory, University of California, P.O. Box 5507, Livermore, California 94526.

Regulatory agencies often face significant problems and costs when scaling up analytical methods to handle large numbers of samples. Immunoassays (IAs) offer for low-cost, high sample-throughput, rapid, and portable alternatives to conventional analytical chemistry methods for analysis (see review in Environ. Sci. Technol. 22:245, March 1988). IA development requires identifying a specific compound of interest, knowledge of its chemistry and metabolism, production of antibodies, characterization of the immunoassay for sensitivity and selectivity, development of a sample work-up method, and validation by comparison with alternative methods where they are available. Eamples of all of these steps will be presented from our own experience developing monoclonal antibodies to toxic contaminants often found in food and environmental samples. We have developed immunoassays for dioxin, pyrethroid and dimetridazole pesticides, and aminoimidazoazaarene mutagens produced in foods by cooking. Work is in progress developing assays for other chlorinated hydrocarbons. The dioxin assays have been validated in a variety of matricies including chemical wastes, PCB transformer oil, fly ash and soils. The pesticide assays have been developed for monitoring meats. These assay typically are sensitive to ng amounts of target chemcial, and show high specificity for the compounds of interest. Immunoassays seem particularly appropriate for compounds which are not readily detected by conventional means because of such factors as their high water solubility, low volitility, thermolability, and similarity to natural compounds present in far greater amounts. A particularly useful application of antibodies it to use them as selective detectors following high performance liquid chromatography (combined HPLC/IA). In addition to using immunoassays for quantification, antibody affinity chromatography can also be used to concentrate and purify trace chemicals.

Antibodies and methods for their use may be licensed from the University of California. Work was performed at Lawrence Livermore National Laboratory under contract from the Department of Energy #W-7405-ENG-48, and funded in part by interagency agreements from the Environmental Protection Agency (#DW 89931433-01-0), the Department of Agriculture (12-37-5-043) and the National Cancer Institute (RO1 CA40811-01).

CURRICULUM VITAE

MARTIN VANDERLAAN

Mr. Vanderlaan received an honours Bachelor of Arts Degree in Physics at the University of California, Santa Barbara (1970) and a Doctor of Philosophy Degree in 1975 at the Institute of Environmental Medicine, New York University Medical Centre, New York.

From 1976 to present he has held the position of Senior Scientist, Biomedical Sciences Division, Lawrence Livermore National Laboratory, University of California, Livermore, California. Previously from 1972-1976 he served as Associate Research Scientist, Institute of Environmental Medicine, New York University.

He has 42 publications to his credit on topics including monoclonol antibodies for the immunoassay of mutagenic compounds produced by cooked meats and for the immunoassay of chlorinated dioxins as well as four patent applications.

BIOTECHNOLOGY RESEARCH PROGRAM IN EPA:

RISK ASSESSMENT AND BIOREMEDIATION

P.H. Pritchard
U.S. Environmental Protection Agency
Gulf Breeze, Florida

The Office of Research and Development in EPA has two major complementary research programs in biotechnology. They address the development of methods and information to a.) assess the ecological risk of releasing genetically engineered microorganisms and microbial pest control agents into the environment, and b.) assist in the evolution of technologies for the remediation of hazardous waste sites using biological treatment processes.

Research in the Risk Assessment program examines the environmental aspects of microorganism detection, survival/colonization, transport, gene exchange and stability, ecological effects and containment/mitigation procedures. A variety of detection systems which are sensitive, specific, and applicable to different environmental media, have been developed by researchers in the program. Environmental, cellular and genetic factors which affect the survival and colonization of microorganisms in a variety of habitats are being investigated. Factors such as ecological niche, environmental surfaces, predation, cell type, and genetic baggage have all been shown to be important. And research is currently underwy to develop predictive models for the transport of microorganisms in different environments and generate the research data required to validate these models.

Recent information produced from the program, suggests that the potential for gene exchange in the environment is possibly quite high but highly dependant on environmental conditions. In addition, single species bioassays, cellular screening tests and microcosms which model specific components of ecosystems are being used to assess potential toxicological responses and interferences with ecological processes. One of several aspects being considered in containment/mitigation is the development, through genetic engineering, of conditional lethal traits that will allow manipulation of environmental conditions at the appropriate time to kill introduced microorganisms.

Many of these risk assessment aspects, will have important applications in bioremediation in that inforamtion on survival, gene exchange, transport, ecological effects, and containment will determine the success, in part, of a biological treatment process.

Research in the bioremediation program is centered around three important aspects; a.) the characterization of biodegradation process useful in the treatment of hazardous waste chemicals, b.) the development of methods and procedures for enhancing the rate, extents and breath of specificity of these processes, and c.) the design and engineering of reactor systems and treatment strategies that successfully optimize the application of the biodegradation processes. The program is not designed to undertake the actual cleanup of a contaminated area, but instead to work in conjunction with commercial firms to evolve the technology and provide the necessary research base to support successful application to a variety of problem areas. Of prime importance is the provision of methods and information to establish the efficacy and environmental safety of a proposed treatment technology. Efficacy is being accomplished through basic research on biodegradation processes in nature, the development of specific guidelines and protocols and facilitated information transfer. Safety is being addressed through the development of toxicity screening assays, containment/mitigation procedures, and a better understanding of the biochemistry of particular biodegradation processes.

Biodegradation research in the program is curently being conducted on a variety of chemicals, including chlorinated solvents, PCBs, chlorinated phenols, petroleum hydrocarbons, creosote, and dioxins. Environmental limitations, anaerobic and aerobic degradation processes, and organism type will be evaluated. Application of this information to liquid and soil reactors, ground water treatment, combined treatment with chemicals and sequential treatment with several types of biodegradation processes has been initiated. As the degradation processes are further characterized, the potential of using genetic engineering to further enhance these process becomes feasible and the interaction with the risk assessment program will allow field application under the safest environmental conditions.

FIELD/LABORATORY EVALUATION OF IN-SITU BIODEGRADATION OF CHLORINATED ALKENES.

Lewis Semprini, Paul V. Roberts, Perry L. McCarty,
Dunja Grbic'-Galic', and Gary D. Hopkins, Department of Civil Engineering,
Stanford University, Stanford, California.

ABSTRACT

Field and laboratory studies have been performed to evaluate the potential for in-situ biotransformation of chlorinated aliphatics, including trichloroethene (TCE), 1,2-cis-dichloroethene (c-DCE), and 1,2-trans-dichloroethene (t-DCE). Enhanced biotransformation was achieved by biostimulating indigenous methane-utilizing bacteria (methanotrophs) that degrade the chlorinated aliphatics as secondary substrates.

The pilot-scale field tests were conducted in a shallow semi-confined aquifer, as a series of stimulus-response experiments, in the presence and absence of biostimulation. The degree of transformation was assessed using mass balances and comparisons with bromide as a conservative tracer. An automated data acquisition and control system controlled the chemical addition, and frequently sampled and analyzed the chemical composition of the injected and extracted fluids and groundwater from three monitoring wells.

In the absence of biostimulation, concentrations of the three chlorinated ethenes broke through nearly completely at the observation wells indicating minimal losses. Biostimulation of indigenous methane-utilizers was achieved after injecting groundwater containing methane and oxygen for a few weeks. A decrease in concentration of the chlorinated ethenes coincided with the utilization of the methane and oxygen. Trans-DCE epoxide, a proposed intermediate product, was also observed. When methane addition was stopped, the concentrations of the chlorinated ethenes increased towards the injected values, while the epoxide concentration rapidly decreased, indicating that biotransformation was associated with active methane-utilization. The degree of biotransformation achieved in the 2 meter biostimulated zone was as follows: TCE, 20 - 30%; cis-DCE, 45 - 55%; and trans-DCE, 70 - 80%. The compound-specific transformation rates were in qualitative agreement with laboratory studies.

Laboratory experiments were performed using batch exchange and continuous flow columns packed with aquifer solids from the test zone, and mixed cultures enriched from aquifer solids samples. The laboratory studies demonstrated the presence of, and the ability to stimulate, methanotrophs that degraded TCE. These methods can provide information for determining the potential of a specific in-situ biological method for a given contamination site.

A non-steady-state biotransformation model was developed that incorporates key processes for microbial growth, including utilization of electron donor, acceptor, and secondary substrates, as well as the transport processes of advection, dispersion, and sorption. Model simulations were in good agreement with the field results. Kinetic parameters determined from the model fits to the field results were in the range of those determined independently in the laboratory studies. These results indicate the potential of combined laboratory and modeling studies in evaluating and designing schemes for in-situ biorestoration.

CURRICULUM VITAE

Lewis Semprini

Lewis Semprini obtained his Ph.D. in Civil Engineering in 1986 from Stanford University, where he carried out research on Modeling and Field Studies of Radon-222 in Geothermal Reservoirs. His Ph.D. was preceded by a Bachelor of Science and a Master of Science in Chemical Engineering, as well as an Engineer's Degree.

Dr. Semprini is currently working as a Research Associate in Environmental Engineering and Science at Stanford University, where he is managing a multidisciplinary research project on in-situ biodegradation methodologies for aquifers restoration. He has published extensively, including 24 acticles between 1980 and 1988, in a variety of professional journals and technical reports. Dr. Semprini is a Registered Chemical Engineer in the State of California and a member of the American Geophysical Union and the Sigma Xi Society.

SESSION II

Whole Effluent Toxicity Testing In The Ontario MISA Program

Gary Westlake

Ontario Ministry of the Environment

Rexdale, Ontario

The management of the toxicity of liquid discharges to aquatic life is a critical element in the regulations being developed under MISA, Ontario's water pollution control program. Whole effluent toxicity testing figures prominantly because it is the only direct measure of the combined environmental significance of a complex mixture of physical and chemical parameters found in most effluents.

Based on a review of the present discharge quality with respect to toxicity, acute lethality tests with trout and *Daphnia* are the most appropriate and effective regulatory tools because many discharges in the province are acutely lethal. Chronic sublethal toxicity tests are used in site-specific water quality based approaches which will become more prominant in subsequent phases of MISA. Regulatory and scientific issues such as effluent pH adjustment, water use credits, single concentration exposures are discussed in the context of Ontario's new pollution control program.

CURRICULUM VITAE

Garson (Gary) F. Westlake

Gary Westlake holds a B.Sc. from McMaster University, Ph.D. from Texas A&M University; he also gained post-doctoral experience working as a Research Associate and Assistant Professor in biological monitoring and computer interfacing at Virginia's Polytechnic Institute and State University from 1972-1974.

For the last 3 years, Mr. Westlake has worked at Ontario's Ministry of the Environment in the Aquatic Contaminants Section of the Water Resources Branch. Previous work experience includes seven years with Environment Canada in the Environmental Protection Service, Atlantic Region, as Head of the Mineral Industries and Toxic Studies Section and as the Marine Environmental Quality Advisor.

CURRICULUM VITAE

Peter G. Nix

Peter G. Nix holds a B.Sc. and an M.Sc. in Microbiology and has considerable expertise in environmental microbiology, aquatic toxicology, tailing pond reclamation and environmental impact assessment.

He is a senior microbiologist with fifteen years experience, presently supervising microbiological services at E.V.S. Consultants. In this capacity he directs ongoing research and evaluation of pathogen and bacterial levels in drinking water supplies, wastewater and receiving environments.

Mr. Nix also has extensive experience in detoxification of xenobiotics involving applied conceptual models, chemical and biophysical designs for biological degradation of toxicants and biological recolorization. His professional experience over the years has involved contract research, preparation of position papers, and routine monitoring for federal, provincial and state agencies, and major municipal districts.

DETECTION OF COLIFORM BACTERIA IN DRINKING WATER USING THE COLIFORM EQUIVALENT (CE) TEST

P.G. Nix and D.B. Holmes, E.V.S. Consultants Ltd. 195 Pemberton Ave., North Vancouver, B.C. V7P 2R4 (604) 986-4331

Synopsis

The Coliform Equivalent (CE) test was developed to address uncertainties regarding the reliability of membrane filtration tests to enumerate coliform bacteria in drinking water and to determine the bacterial quality of source water supplied to a major Canadian city. Results confirmed the ability of the CE test to quantitatively enumerate coliforms using resazurin reduction as a measure of bacterial dehydrogenase enzyme activity. As a consequence of using metabolic activity rather than cell division as a estimate of cell numbers, the CE test was shown to be a more sensitive monitor of coliform cell numbers in chlorinated water compared with membrane filtration tests and therefore could be a predictive tool for bacterial regrowth problems within drinking water distribution systems.

The CE test may be superior to membrane filtration tests regarding: (1) evaluation of bacterial water quality in water containing stressed coliforms (i.e., chlorinated source water); (2) determination of disinfection effectiveness; and, (3) assessment of coliform incursions during periods of high turbidity. The test protocol is simple and adaptable for use in the field by water treatment operators. Test results can be obtained in less than 12 hours, so a rapid response to evidence of poor water quality is possible (e.g., increased chlorination). Extensive field testing is in progress to confirm these results.

ABSTRACT

MICROBIOLOGICAL REGENERATION OF GRANULAR ACTIVATED CARBON FOR INDUSTRIAL WASTEWATER TREATMENT

C.W. Robinson and D.H. Hutchinson, Dept. of Chemical Engineering, University of Waterloo, Waterloo, Ont., Canada N2L 3G1

Biological regeneration is one method of recovering the adsorptive capacity of spent activated carbon for industrial wastewater treatment, and is especially attractive in the case of effluents containing bio-inhibitory dissolved organics (e.g., phenolics, aromatics). The spent carbon is contacted with a culture of microorganisms having high biodegradation rates of the target organics after their desorption from the carbon particles. For design and scale-up purposes, accurate prediction of the time required to regenerate the carbon is essential, as well as enumeration of the effects of the relevant operating variables.

We have developed a computerized model of both the adsorption and the regeneration cycles of a carbon treatment-regeneration process, and have experimentally verified it for a phenol-cresol bisolute model synthetic wastewater system. The model incorporates transport phenomena (internal and external diffusion resistances), carbon isotherms and microbial growth and biodegradation kinetics. In terms of the breakthrough(s) of phenolics during loading after regeneration, good agreement was found between experimental observations and predictions for fixed beds of granular carbon that had been bio-regenerated for up to six times, provided that microbial fouling of the carbon was prevented.

The major factors affecting biological regeneration of granular activated carbon will be presented and discussed. Existing bottlenecks to the commercialization of this process will be identified, and potential solutions indicated.

CURRICULUM VITAE

CAMPBELL W. ROBINSON

Mr. Robinson holds a Bachelor of Applied Science Degree in Chemical Engineering from the University of British Columbia and a Doctor of Philosophy in Chemical Engineering from the University of California, Berkeley. He is presently Professor, Chemical Engineering, University of Waterloo having worked previously with Gulf Canada Ltd. Mr. Robinson's current research interests include industrial wastewater treatment; low-temperature biodegradation; fluidized-bed reactors; microbial regeneration of activated carbon and the production, recovery and purification of foreign protein products using recombinant microorganisms.

His professional activities include editorships, consulting and serving on the NSERC Strategic Biotechnology Grants Selection Panel.

CURRICULUM VITAE

Alexandra Kantardjieff, P. Eng., M.Sc.A.

Mrs. Kantardjieff holds a bachelor's degree from the University of Sofia, Bulgaria and a Masters Degree in Environmental Engineering from the University of Minnesota, U.S.A., since 1979.

Member of Quebec Order of Engineers, AQTE, WPCF, CSCE and TAPPI, Mrs. Kantardjieff is also a licensed professional engineer in Arizona and Nevada, U.S.A.

She is with Groupe Teknika since 1972 where she is an associated partner since 1987. In charge of the department of industrial wastewater treatment and applied R & D, she has accumulated also a solid experience in the municipal wastewater treatment plant design and construction.

Her previous research work included among others: nitrification kinetics studies; municipal and pulp and paper effluents joint treatment; municipal wastewater disinfection alternatives; municipal and textile effluents joint treatment; and RBC evaluation.

FIRST CANADIAN FULL SCALE BIOLOGICAL AERATED FILTER FOR WASTEWATER TREATMENT CANTON ORFORD, QUEBEC

A. Kantardjieff
Groupe Teknika
Sherbrooke, Quebec

The small city of Canton d'Orford is located in the base of one of the biggest Quebec ski areas - Mont Orford. As usually found in such locations, the permanent residents represent only a small fraction of the peak ski season's population.

The great wastewater variations, from season to season and from weekdays to weekends (10:1), combined with very stringent effluent criteria (15/15/0.5) and severe deadlines required a special design and construction approach for the upgrading of the existing wastewater treatment plant.

To take care of the important wastewater flow variations, half of the existing IMHOFF tank was converted to an equalisation basin. The BOD load to the secondary treatment is smothened by physico-chemical primary treatment with ferric chloride coagulation and lamella settler clarification.

The biological portion of the treatment is achieved by two aerated biologial filter cells. This treatment does not need secondary clarification, so the effluent is only disinfected by UV before discharge to the Cherry River. Half of the treated water is infiltrated into the ten existing leaching fields (140,000 sq. ft. of 0.5 mg/l.

Since the start up in April 1988, the plant has produced constantly an effluent of 10/10/0.3 of BOD, SS and Pt respectively with a minimal operator's attention.

This performance confirms the initial expectations and places the process as one of the most promising wastewater treatment technologies of the future.

CURRICULUM VITAE

ERIC HALL

Mr. Hall holds Bachelor and Master of Science degrees in Biochemistry and a Doctor of Philosophy Degree in Chemical Engineering from McMaster University.

He is a Process Development Engineer with Environment Canada in the Biological Processes Section at the Wastewater Technology Centre, Burlington, Ontario. He is also a part-time Assistant Professor, Department of Civil Engineering and Engineering Mechanics, McMaster University.

Mr. Hall's research activities cover biological treatment of industrial wastewaters with emphasis on reactor design kinetics, modelling and process control of anaerobic treatment processes. Additional activities involve the development of integrated physiochemical-biological processes for the removal of toxic constituents of pulp and paper wastewaters.

CURRICULUM VITAE

PATRICK J. WRIGHT

Mr. Wright received a Bachelor of Science Degree in Civil Engineering at the University of Vermont, U.S.A., and a Master of Science in Environmental Engineering from Cornell University. He has 15 years experience in the consulting engineering industry, much of this in the fields of water and wastewater treatment. He is presently a senior project manager and designer with Porter Dillon Limited in Halifax, Nova Scotia, where he oversees all treatment work conducted by the Company.

Mr. Wright served as the project manager and chief designer of the Highway 101 Landfill Leachate Treatment Facilities (Halifax County) and was involved in the project from its initial lab phase through to the start-up and commissioning.

REMOVAL OF PULP AND PAPER WASTEWATER TOXICS BY ANAEROBIC TREATMENT

E.R. Hall
Environment Canada
Wastewater Technology Centre
Burlington, Ontario

W. Parker & G. Farquhar
Civil Engineering
University of Waterloo
Waterloo, Ontario

In April 1988, the Ontario Ministry of the Environment received the final report of the Expert Committee on Kraft Mill Effluent Toxicity. One of the recommendations made by the committee called for the inclusion of organochlorine as a regulated parameter within any revised effluent guidelines for the pulp and paper industry. Organochlorine compounds are produced during the bleaching of pulp with chlorine, chlorine dioxide and hypochlorite. A recent survey of Ontario bleached kraft mills indicated that current organochlorine discharges are as much as 400% in excess of the lowest regulatory level recommended for the province.

One potential treatment approach for organochlorines in pulp and paper effluents involves the application of anaerobic biotechnology. Previous studies have demonstrated that low levels of chlorinated aromatics may undergo reductive dehalogenation in an anaerobic environment. Since reductive dehalogenation appears to enjoy more favourable kinetics than oxidative metabolism, the efficiency of chloroaromatics removal by anaerobic biotreatment is likely to be higher than that obtainable in an aerobic process.

Several measurements made at the Wastewater Technology Centre have confirmed that pulp bleach plant effluents contain relatively high concentrations of organochlorine. A number of bioassay experiments demonstrated that, although this material is very inhibitory to methanogenic bacteria, it is possible to develop acclimated anaerobic populations for the production of methane in the presence of bleach plant wastewater. Preliminary monitoring of a low rate semi-continuous anaerobic reactor indicates that approximately 55% of the wastewater organochlorine (measured as adsorbable organic halogen, AOX) can be removed during anaerobic treatment. Analysis of a number of specific chlorinated aromatic compounds suggests that many tri- and tetra-chloroaromatics are almost completely removed. A small number of di-chloro compounds show evidence of accumulation during anaerobic treatment.

HIGH RATE ANAEROBIC TREATMENT

OF A LANDFILL LEACHATE

THE HALIFAX EXPERIENCE

By P.J. Wright, P. Eng.

Porter Dillon Limited

Halifax, Nova Scotia

The Highway 101 Regional Landfill was developed in 1976 and currently receives 1,100 tons of refuse from Halifax, Dartmouth, Bedford and Halifax County. This refuse is primarily of a municipal and commercial nature with no hazardous or toxic wastes permitted. Leachate is collected in an underdrain system and directed to treatment, previously provided by two aerated lagoons. The inability of the lagoon system to handle increasing strength and quantities led to a project to upgrade treatment capability.

The leachate from this landfill is characterized generally by high strengths and low flows. COD values in excess of 20,000 mg/L are common and much of this is comprised of volatile acids. A high rate anaerobic treatment system was selected for investigation and tested through lab and pilot programs before the full scale system was implemented.

The installed system consists of four stages including:

- pretreatment to adjust pH and remove inhibitory metals,
- anaerobic reactors to reduce organic strength,
- sludge handling facilities, and
- polishing lagoons.

These are illustrated in the process schematic.

The anaerobic reactors have been designed and constructed as combination upflow sludge blanket reactors. Two units exist, each with 135 m3 of effective reactor volume. A cross section illustrates the basic components of the reactor. Design loading rates are 7.0 kg COD/m3.day initially increasing to 9 kg COD/m3.day under ultimate conditions.

The system has been operating since late Spring 1987. Following the initial start-up period, the high rate anaerobic reactors have consistently achieved in the order of 90% COD removal at volumetric loading rates ranging (as a function of leachate flows and quality) from 4 to 7 kg COD/m3.day.

Pictures of the facility are presented along with capital and operating costs.

MEMBRANES IN BIOTECHNOLOGY
A RESEARCH AND DEVELOPMENT CASE STUDY

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ABSTRACT:

Several established techniques in the biotechnology industry use membranes to effect separations and purifications. There are many opportunities for new applications for membranes in biotechnology, although the development of highly specialized applications has been limited by the moderate number of relatively small systems that such an application may generate world wide. Continued improvements in fermentation technology are nevertheless expected to fuel increasing demand for membranes in the industry. As well, cold sterilization using membranes that quantitatively remove bacteria and pyrogens is expected to create opportunities.

Membrane processes can be divided into three major categories. Reverse osmosis (RO), ultrafiltration (UF), and microfiltration (MF). RO is used to desalinate brackish or sea water, and can also be used to remove dissolved organic species. UF can be used to remove macrosolutes such as proteins and water soluble polymers as well as colloids. MF can be used to remove colloids and suspended particulate matter. UF and MF function on the basis of size exclusion by porous membranes, and as such are only applicable to distinguishing between solutes whose sizes differ by at least an order of magnitude.

In this presentation we discuss a research and development case study of a commercialization of a biotechnology process utilizing membranes. The process is based upon the concept of affinity ultrafiltration as developed by scientists at NRC[1]. In this method a functionalized polymer which selectively complexes to a specific solute is used to prevent its passage through an ultrafiltration membrane by increasing its effective size. Other solutes of similar (original) size pass through the membrane. The technique was demonstrated at the laboratory scale at the Biotechnology Research Institute in Montreal to effect the separation of trypsin from chymotrypsin. Zenon's involvement has entailed the system development and process engineering required to scale up the process in a commercially viable fashion. Process optimization has included studies of fluid rheology, shear studies of the various macrosolutes, and the development of suitable membranes and membrane cleaners. Further development areas include the design of suitable process equipment.

A technoeconomic assessment performed at Zenon has shown the trypsin purification to be economically feasible. Using this method to effect separations of more valuable substances such as urokinase look very promising. In addition the technique holds considerable promise in environmental applications such as the removal / recovery of toxic heavy metals from process waste streams. Zenon is currently initiating an R&D effort to realize this for a variety of metals.

References: 1 a) J.H.T. Luong, K.B. Male, and A.L. Nguyen, Biotechnology and Bioengineering, 31, 516-520 (1988) b) J.H.T. Luong, K.B. Male, and A.L. Nguyen, Biotechnology and Bioengineering, 31, 439-446 (1988)

CURRICULUM VITAE

R.D. Thomson

Mr. Thomson received a Bachelor of Science Degree in Chemistry in 1977 from the University of Western Ontario. He joined Zenon Environmental Inc., Burlington, Ontario in 1982 as Senior Chemist for the Analytical Services Group. Mr. Thomson is presently Manager of the Chemistry Section of the Membrane Division supervising a staff of four chemists and engineers. The Division's main responsibility is the development of new membrane products in the areas of MF, UF and reverse osmosis expanding technology into the microfiltration range.

He has taken a lead role as project manager in a number of government funded R & D projects including the biotechnology area. Most recently Mr. Thomson has supervised membrane, process and system development for affinity ultrafiltration products slated for market introduction in 1989.

CURRICULUM VITAE

Dr. D. Roy Cullimore

Director of the Regina Water Research Institute and Professor of Microbiology, University of Regina, Regina, Saskatchewan. Educated in the U.K. at the University of Nottingham with degrees in Agricultural Science and Agricultural Microbiology. Taught at U. of Surrey, U.K. for six years before coming to Regina. Co-chairperson of AWRA International Symposium on Biofouled Aquifers in Atlanta, 1986 and also Technical Workshop on Iron Bacteria. Hosted a Think Tank on this topic in Regina same year. Co-inventor of the (US patented) Blended Chemical Heat Treatment of Biofouled Wells now being evaluated by the US Corps of Engineering. Has published extensively in applied microbial ecology. Present research centers around the diagnosis and restoration of biofouled water wells, control of black plug layer in sand putting greens and upgrading the efficiency of septic tank reactors.

BIOLOGICALLY FOULED WATER WELL MONITORING AND RESTORATION

D. Roy Cullimore

Regina Water Research Institute
University of Regina
Regina, Saskatchewan

Water wells have long been known to suffer from production losses due to the various clogging (plugging) processes occuring close to or at the well screen/aquifer interface. While some of this can be caused by direct chemical and/or physical processes, research now indicates that there can be a major biological component to this clogging. Laboratory model wells have been established through which the effects of a biological clogging (biofouling) can be monitored by observing interstitial space volume diminution and higher resistance patterns to water flow through the model wells. Using laboratory and field cases, a strategy for the monitoring of water wells potentially biofouled is being developed. This involves a detailed evaluation of the types of particles released in the discharge waters (e.g. pigmentation, size, relative biomass component and microbial composition). As the biofouling occurs so the particulate composition will shift thus facilitating the monitoring process. The structure of this evaluation process will be discussed from the management standpoint and applied in the laboratory when modelling the impact of the B.C.H.T. (U.S. patented) process to remediate biologically driven clogging conditions.

SESSION III

STRATEGIC PARTNERSHIPS IN BIOTECHNOLOGY

ASSOCIATIONS STRATÉGIQUES EN BIOTECHNOLOGIE

CURRICULUM VITAE

STEPHEN SHUGAR

Mr. Shugar received an honours Bachelor of Science Degree in Genetics at McGill University in 1969 and a Masters of Science in Bacterial Genetics, University of Calgary in 1971.

He is presently Assistant Director, Strategic Grants, Natural Sciences and Engineering Research Council, responsible for the development, recommendation and implementation of policies and programs designed to enhance research capabilities in areas of national strategic importance.

Before joining NSERC in 1979 he served for two years as a Research Council Officer in the NRC Environmental Secretariat responsible for the composition of a report on the health effects of asbestos based on a critical analysis of the published literature.

He has conducted research on drug-resistant mammalian cells in culture and published on the characterization of a muicoid Escherichia coli K12 strain and chemical analysis of the exopolysarcharide.

CURRICULUM VITAE

Denys Cooper

Mr. Cooper has had extensive experience with grant programs both from the industry side and more recently the government side.

He joined NRC's Industrial Research Assistance Program in 1973 and is now involved in the expanded technology transfer program.

Denys Cooper has a PhD in polymer science from the University of Liverpool in England. In 1965 he took a 2 year post-doctoral fellowship at NRC.

As a change of pace he is an international field hockey umpire.

NSERC - A PARTNER IN BIOTECHNOLOGY RESEARCH

S. Shugar

The Natural Sciences and Engineering Research Council has a mandate to promote and assist research in the natural sciences and engineering other than the health sciences. As such it provides approximately 35% of the external research and development support for Canadian universities in the natural sciences and engineering. With budget which has almost tripled over the past decade, NSERC has supported a broad array of university-based research through a number of different programs.

More than 57% of the $354 million 1988-89 budget is devoted to the Research Base programs, primarily the Operating and Equipment and Infrastructure Grants. Within the Operating Grants program, grantees are not restricted to specific projects but rather they pursue self-defined research interests. Close to 7,000 university researchers hold NSERC Operating Grants.

Over 17% of the budget is designated for programs of Targeted Research. Whereas the operating grants are primarily long-term research of both a basic and applied nature, the University-Industry program and the Strategic Grants program are project oriented. The Strategic Grants program has the objective of enabling university researchers to make contributions in the understanding of problems of national concern through specific applied research having potential for relatively short-term socio-economic benefits or through more basic research designed to develop knowledge in areas of socio-economic importance. One of the designated areas for which applications are accepted is "Biotechnology"; and, "Environmental Toxicology", possibly will have its mandate broadened to "Environmental Management". Interaction with the user sector is encouraged. In the University-Industry program, the focus is on collaborative research activity and on the transfer of pre-competitive research results to the user sector. The active participation of a company in a project is a pre-requisite for support.

Through these many programs (not counting the $60 million manpower programs of Scholarships and Post Docs), it is estimated that NSERC supports approximately $17 million of research per year which falls within the realm of Biotechnology - more than half of this is through the program of Operating Grants. Some portion of this research is directed towards improving the environment (e.g. wastewater treatment, PCB degradation and drinking water treatment).

NSERC actively encourages interaction between the academic, industry and government research sectors. It makes readily available lists of grants awarded in given areas of research and offers grant programs where joint funding of

AN UPDATE ON THE SCOPE AND OPERATIONS OF THE NRC'S INDUSTRIAL RESEARCH ASSISTANCE PROGRAM, AND HIGHLIGHTS OF THE RECENT R & D TAX CHANGES

By Dr. Denys Cooper

IRAP of NRC

Ottawa, Ontario

Denys Cooper will discuss the expanded role of IRAP with projects involving pre-competitive R&D linking government and universities with industry. A range of consortia arrangements can be tailored to meet the interests of the parties involved. There is a specific interest in developing projects using biotechnology.

Canada provides 2-4% of the world technology. An expanded interest has been generated in developing routes to access the world technologies relevant to Canadian industry. The NRC's new Technology Brokers program will be discussed as well as the hands on approach being taken by project managers of IRAP to link foreign technologies to firms in Canada.

Finally, a short review will be made on the recent tax changes on R & D and how they affect small companies will be given.

INDUSTRY SCIENCE AND TECHNOLOGY CANADA

STRATEGIC PARTNERSHIPS IN BIOTECHNOLOGY

Dr. Elizabeth Dickson

Director

Biotechnology and Health Care Products

The new Department of Industry, Science and Technology has been created as a "flagship" for the government's economic development efforts. The mission of this "flagship" economic department will be to promote wealth generation and competitiveness through development of industry, science and technology in all parts of Canada and across all sectors; and to promote excellence in science.

The Directorate of Biotechnology and Health Care Products is playing a key role in the delivery of this promotional effort through the Headquarters staff, the National Biotechnology team and the System of Biotechnology Networks.

Numerous federally administered programs are available to assist Canadian biotechnology firms in developing and commercializing their products both in the Canadian marketplace and abroad. The proposed Strategic Technologies Program will be an important addition to these programs offering new incentive to maximize industrial applications and commercialization potential of biotechnology through formation of R&D Alliances and Technology Application Alliances.

The National Biotechnology Strategy, launched in 1983, focussed during its first five years on strengthening the R&D community upon which development of biotechnology relies. BIOQUAL, established in 1986 as part of this strategy, has grown to a membership of 350. At the same time, the number of firms engaged in biotechnology applications to environmental problems has grown to approximately 50.

As we enter Phase II of our National Biotechnology Strategy, the focus has been broadened beyond R&D to include the full range of development activities that precede commercialization. In addition, as industry advocate, the Department of Industry, Science and Technology will work closely with industry and government colleagues to improve the overall policy climate for biotechnology in Canada. In this way, by fortifying the partnerships among industry, the scientific community and government; by working together to remove the obstacles to success; by harnessing the best technology that can be found; together we can ensure that this dynamic industrial sector plays a significant role in Canada's economic future.

CURRICULUM VITAE

Dr. Elizabeth Dickson

Dr. Elizabeth Dickson began her career as a quality control chemist for Consolidated Bathurst at the pulp mill in Portage-Du-Fort, Quebec. From 1970 until 1981 she worked at the University of Texas at Austin and then at the Rockefeller University in New York City. During this time, she obtained her doctorate in molecular genetics, joined the faculty at Rockefeller, and pursued a broad basic research program which focussed on the role of RNA in gene expression. In 1981 she entered the private sector as a partner in a printing and publishing firm where she took on responsibilities in financial management and journalism. From 1984 to 1987 Dr. Dickson worked as Legislative Assistant and Policy Advisor to a Member of Parliament. In November 1987 she joined the Department of Regional Industrial Expansion as the Director of Biotechnology and Health Care Products.

BIOQUAL '88 SYNOPSIS

SYNOPSIS DE BIOQUAL '88

BIOQUAL '88 SYNOPSIS

BIOMONITORING, BIOSENSING AND BIODEGRADATION

Peter Ian Forrester

Mr. Forrester is President and General Manager of Gemini Biochemical Research Ltd. of Calgary, Alberta responsible for the company's biochemical and chemical research activities.

He received an honours Bachelor of Science Degree in Chemistry in 1967 from the University of Edinburgh, Scotland and a Doctor of Philosophy Degree from the University of Calgary, Alberta in 1971.

While a Post-Doctoral Fellow, Division of Medical Biochemistry, University of Calgary, his work revolved around the oncofetal gene product known as alpha-fetoprotein establishing radio immunoassays for both human and rat alpha-fetoproteins. He has published a number of papers based on his work at the University of Calgary.

From 1977 to 1981 he was Research Manager, Geochem Laboratories (Canada Ltd.) Calgary, Alberta responsible for setting up and running of a petroleum testing laboratory.

BIOQUAL'88 SYNOPSIS

BIOPROCESS ENGINEERING

Keith L. Murphy, P. Eng.

Mr. Murphy has a Bachelor of Applied Science Degree in Civil Engineering from the University of Toronto. A Masters Degree in Civil Engineering and a Doctor of Philosophy Degree in Civil Engineering both from the University of Wisconsin.

He is presently Texaco Canada Professor of Environmental Systems Engineeering, Department of Civil Engineering and Engineering Mechanics, McMaster University, Hamilton, Ontario.

Principal with Beak Consultants Limited for 12 years, he was responsible for the technical quality of projects on wastewater design, water quality, environmental modelling and technology development. He also acted as an expert witness on behalf of clients at public meetings and environmental hearings.

Mr. Murphy authored or co-authored approximately 70 technical papers on environmental engineering on industrial and municipal water and wastewater treatment including: biological wastewater treatment, nitrogen removal, highrate anaerobic processes, ozonation, chlorination, gamma radiation, oxygen transfer and utilization, flocculation, granular filtration, and sludge treatability.

A member of a number of professional organizations he is presently President, Canadian Asociation on Water Pollution Research and Control and a member of the Reconsideration Committee, Association of Professional Engineers of Ontario.

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Microbics Enterprises, Forest, Ontario

W.H.E. Process Systems Limited, Weston, Ontario

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IRAP Laboratory Network, NRC, Ottawa, Ontario

Publication: "Sciences et techniques de l'eau"

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